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Chapter Fifty-five

GEOMETRIC DESIGN OF EXISTING NON-FREEWAYS (3R)

55-1.0 INTRODUCTION

Section 40-6.0 of the *Indiana Design Manual* identifies seven project scopes of work:

1. new construction,
2. complete reconstruction (freeways),
3. partial reconstruction (4R) (freeways),
4. reconstruction (4R) (non-freeways),
5. 3R projects (non-freeways),
6. 3R projects (freeways),
7. resurfacing projects (non-freeways),
8. high-accident location improvements (non-freeways), and
9. traffic control device projects.

Chapter Fifty-three presents tables of INDOT's geometric design criteria which apply to new construction/reconstruction projects. In addition, Chapters Forty through Fifty-two present many design concepts and criteria which are directly applicable to new construction/ reconstruction. For these projects, the designer typically has the liberty of designing the highway to meet the most desirable and stringent criteria practical.

The geometric design of projects on existing highways usually is viewed from a different perspective. These projects are often initiated for reasons other than geometric design deficiencies (e.g., pavement deterioration, bridge replacement), and they often must be designed within restrictive right-of-way, and financial and/or environmental constraints. Therefore, the design criteria for new construction are often not attainable without major and, frequently, unacceptable adverse impacts. At the same time, however, the Department must use the opportunity to make cost-effective, practical improvements to the geometric design of existing highways and streets.

For these reasons, INDOT has adopted different limits for geometric design criteria for projects on existing highways which are, in many cases, lower than the values for new construction. The criteria for existing highways are based on a sound, engineering assessment of the underlying principles behind geometric design and on how the criteria for new construction can be modified to apply to existing highways.

This chapter presents the Department's criteria for 3R non-freeway projects. These criteria balance the many competing and often conflicting objectives. The objectives include improving Indiana's existing highways, minimizing the adverse impacts of highway construction on existing highways, and improving the greatest number of kilometers within the available funds for capital improvements. In all cases where the 3R project scope of work is selected, costly items (e.g., bridge reconstruction/replacement, alignment improvements), which have a long service life and can be incorporated into a future 4R project, should desirably be constructed to meet 4R design criteria as part of the 3R project.

55-2.0 GENERAL

55-2.01 Applicability

55-2.01(01) 3R Scope of Work Definition

3R projects (rehabilitation, restoration and/or resurfacing) on existing non-freeways are primarily intended to extend the service life of the existing facility and to enhance highway safety. In addition, 3R projects should make cost-effective improvements to the existing geometrics, where practical. 3R work on the mainline or at an intersection is typically work on the existing alignment. Minimal right-of-way acquisition is often required. Typical improvements for 3R non-freeway projects may include any combination of the following:

1. pavement resurfacing or rehabilitation and/or a limited amount of pavement reconstruction (30% or less of the traveled way area);
2. bridge rehabilitation or replacement;
3. lane and shoulder widening;
4. upgrading the structural strength of shoulders;
5. flattening an occasional horizontal or vertical curve;
6. adjustments to the roadside clear zone;
7. flattening side slopes;
8. converting an existing median to a 2-way left-turn (TWLT) lane;

9. adding a climbing lane;

10. converting an uncurbed urban street into a curbed street;

11. revising the location, spacing or design of existing driveways along the mainline;

12. adding or removing parking lanes;

13. bridge widening and associated substructure work to accommodate the widening;

14. bridge rail upgrading or replacement;

15. bridge deck overlays;

16. work to preserve the bridge substructure;

17. adding sidewalks;

18. relocating utility poles;

19. upgrading guardrail and other safety appurtenances to meet certain criteria;

20. other geometric and/or safety improvements to existing bridges within the project limits;

21. drainage improvements;

22. increasing vertical clearances at underpasses;

23. intersection improvements (e.g., adding turn lanes, flattening turning radii, channelization, corner sight distance improvements, etc.);

24. adding new or upgrading existing traffic signals; and/or

25. other spot improvements.

Specifically related to the level of pavement improvement, the following definitions apply:

1. Resurfacing. Resurfacing consists of the placement of additional surface material over the existing restored or rehabilitated roadway or structure to improve serviceability or to provide additional strength.

2. Restoration/Rehabilitation. Restoration/rehabilitation is defined as work required to

return the existing pavement to a condition of adequate structural support or to a condition adequate for the placement of an additional stage of construction. This may include milling the existing pavement.

55-2.01(02) National Highway System (NHS) Projects

For long-range transportation planning purposes, INDOT has evaluated the State highway system to determine which routes warrant reconstruction (or 4R) and which routes warrant a 3R-type improvement. Figure 55-2A presents a map of the Indiana State highway system to indicate 3R and 4R routes within the State. The following will apply to the use of Figure 55-2A for those 3R and 4R routes on the NHS.

1. General. In general, two major factors will determine if the project should be classified as 3R or 4R:

    a. If 70% or more of the existing pavement area of the traveled way can be retained and resurfaced, the project may be classified as 3R. If not, the project is typically a 4R project.

    b. An assessment of the level of service (LOS) for the 10-year traffic volume projection, which is based upon the expected service life of the pavement, can be used to determine if the project is 3R or 4R.

    Other factors should also be considered when making the project scope of work determination (e.g., accident rates).

2. 4R Non-Freeway Routes. The Environment, Planning and Engineering Division or the local jurisdictional agency will determine the level of service (LOS) for the 10-year traffic volume projections based on the discussion in Section 40-2.0. If this is LOS D or better, then it will be acceptable to design the project using the 3R geometric design criteria in this Chapter. If the projected LOS will not meet LOS D, the facility will typically be designed according to the criteria for new construction/reconstruction. All bridge replacements, bridge deck replacement and bridge widening projects should be designed to meet new construction or 4R criteria.

3. 3R Non-Freeway Routes. The project will typically be designed according to the 3R geometric design criteria in this Chapter. However, consideration could be given to using the 4R criteria.

4. Combination Projects. Where a project will include both 3R and 4R work, the overall

project scope of work classification should be based on the predominant type of work.

For example, a 10-km resurfacing project which includes the replacement of one of the mainline bridges (to 4R criteria) would generally be classified as a 3R project, unless the bridge is considered to be a major structure and its replacement cost is equal to or greater than that of the 3R roadway work.

55-2.01(03) Non-NHS Projects

The project scope of work definitions in Section 40-6.01 and Figure 55-2A, 3R/4R Systems, are intended only as general guidance on non-NHS projects. The decision on classifying a project that is not on the NHS should desirably be made based on the future plans of the jurisdictional highway agency for the entire road between logical termini for the foreseeable future (20 years). All future plans for a road must consider current and projected traffic volumes, anticipated land use and accident experience. The following presents several examples of applying this concept to non-NHS projects.

1. Example 1. Approximately 60% of the pavement on a 10-km section of a county road will be replaced. The remainder of the pavement is in reasonably good condition and only requires milling and resurfacing. The 10-km section is part of a 50-km county road which is the main highway between two small towns. The existing road has a LOS A, and it is anticipated to provide a LOS B based on 20-year projected traffic volumes. There is no adverse accident experience for the last three years. Based on this information, a highway agency could decide to designate the 3R classification and construct the road to 3R design criteria. This is acceptable even though more than 30% of the pavement is being completely replaced.

2. Example 2. Approximately 40% of the pavement on a 10-km section of county road will be replaced. The remainder of the segment will be resurfaced. This segment of road is part of a 40-km county road which connects two small towns. This county road is located approximately 30 km from a major metropolitan area. It is anticipated that, within the next 20 years, there will be considerable residential and commercial development adjacent to this stretch of county road because of its proximity to the rapidly expanding metropolitan area. The current LOS is B, but projected traffic volumes indicate that the LOS will drop to D in 10 years and to F in 20 years. In this case, the highway agency has two options. They could decide to design the project to 3R criteria for the present and, then, undertake a 4R project in 10 years when the pavement will likely be in need of major work. Their second option would be to construct the project to 4R criteria now to meet future traffic demands.

3. Example 3. A 10-km section of highway, which is located on INDOT's 3R highway system, requires complete pavement replacement because of poor drainage. The Central Office has rechecked the status of this highway with the district office and verified that there are no plans for work on the remainder of this route in the future (20 years) except for 3R-type work. The current LOS is B, and it is anticipated to remain at B for the next 20 years. There is no adverse accident experience and no anticipated major land development along the route. INDOT could decide in this case to only construct the project to 3R design criteria, even though all of the pavement is being replaced.

4. Example 4. A 60-m long bridge on the State's 3R system requires complete replacement. In addition, there are sharp horizontal curves on each end of the bridge where numerous accidents have occurred during the last three years. It has been decided to correct the poor alignment on the bridge approaches and to construct the approaches and bridge on a new location. The total length of the project is 2.5 km. The Central Office has discussed the status of this road with the district office and both agreed that it should remain on the 3R system. The current LOS is B, and it is estimated that the LOS will be C in 20 years. There are no plans except to perform 3R-type work to the remainder of the road for the future (20 years). In this case, INDOT could decide to construct the entire project to 3R design criteria.

5. Example 5. A 10-km segment of a route on INDOT's 3R system requires replacing 20% of the pavement and resurfacing the remaining 80%. The current LOS is D and will deteriorate to E in 5 years. There is rapid residential, commercial and industrial development in the area. Both the Central and district offices agree that the entire route was properly classified as a 3R route. However, this one 10-km segment is an exception because rapid growth adjacent to this 10 km segment is expected to occur. The appropriate solution in this case would be to upgrade the facility to accommodate any anticipated traffic demand for the next 20 years and to design the project to 4R design criteria.

55-2.01(04) Procedures

For INDOT projects, the project scope of work is selected based on the following procedure:

1. The district office initially identifies the project scope.

2. The project is programmed based on the project scope determined by the District.

3. The Environment, Planning and Engineering Division will make the final decision on the scope of work for the project. However, for all Interstate system projects which have an

estimated construction cost exceeding $1 million, FHWA will meet with representatives of the Environment, Planning and Engineering Division to cooperatively agree on the project classification. This will occur as early in the project scoping process as possible so that FHWA can have input on those projects which are classified as 4R. The meeting normally will be held as soon as an initial concept for the project design has been developed.

4. The Division of Design, during project design, may re-evaluate the project scope and request the Environment, Planning and Engineering Division to modify the scope of work.

For Federal-aid projects not on the State highway system, the project scope of work determination will be based on the future plans of the local agency for improvements to its local road or street system. The philosophy presented in Section 55-2.01(02) Item 2 for 4R non-freeway State routes should also be applied to local projects. The local agency must submit a letter to the Program Development Division to document the local agency's plans on that facility in the foreseeable future. If the project is on the Interstate system and the estimated construction costs exceed $1 million, the Program Development Division will schedule a meeting with the local agency and the FHWA to determine the project's classification (3R or 4R). This meeting should occur early in the scoping process so that the FHWA can have input on those projects that are classified as 4R.

55-2.02 Background

The 1976 Federal-aid Highway Act made it possible for State and local agencies to use Federal funds to extend the service life for the maximum number of kilometers possible for the total highway system. On June 10, 1982, the FHWA issued its Final Rule entitled "Design Standards for Highways; Resurfacing, Restoration and Rehabilitation of Streets and Highways Other Than Freeways." This rule modified 23CFR Part 625.4 to adopt a flexible approach to the geometric design of 3R non-freeway projects. Part 625.4 was modified again on March 31, 1983 to explicitly state that one objective of 3R projects is to enhance highway safety. In the rule, FHWA determined that it was not practical to adopt 3R design criteria for nationwide application. Instead, each State can develop its own criteria and/or procedures for the design of 3R projects. This approach is in contrast to the application of criteria for new construction and reconstruction, for which the AASHTO *A Policy on Geometric Design of Highways and Streets* provides nationwide criteria for application. This flexible approach allows each State to tailor its design criteria for its 3R program consistent with the conditions which prevail within that State. Highways for which geometrics were established some years ago are still capable of providing useful transportation service. In most cases, minor improvements will make such highways serviceable for many more years.

In 1987, the Transportation Research Board (TRB) published Special Report 214 *Designing Safer Roads; Practices for Resurfacing, Restoration and Rehabilitation*. The objective of the TRB study was to examine the safety cost-effectiveness of highway geometric design criteria and to recommend minimum design criteria for 3R projects on non-freeways. The designer should reference SR214 for more discussion on 3R projects.

INDOT has developed its own criteria for the geometric design of 3R non-freeway projects. Its objectives in developing this criteria may be summarized as follows:

1. 3R projects are intended to extend the service life of the existing facility and to return its features to a condition of structural or functional adequacy.

2. 3R projects are intended to incorporate highway safety enhancements, where judged to be cost effective.

3. 3R projects are intended to incorporate cost-effective, practical improvements to the geometric design of the existing facility.

55-2.03 Approach

The Department's approach to the geometric design of 3R non-freeway projects is to adopt, where justifiable, a revised set of numerical criteria. The design criteria throughout the other chapters in the *Indiana Design Manual* provide the frame of reference for the 3R criteria. The following summarizes the approach which has been used.

1. Design Speed. As discussed in Section 55-4.01, the design speed will normally be based on the existing posted or legal speed limit. The selected 3R design speed will then be used to evaluate all geometric design features of the existing highway which are based on speed (e.g., horizontal and vertical curvature).

2. Cross Section Widths. The criteria in Chapter Fifty-three for new construction/ reconstruction have been evaluated relative to the typical constraints of 3R projects. Where justifiable, the cross section width criteria have been reduced. Where a range of values is provided in the Chapter Fifty-three tables, the upper values have been incorporated into the 3R criteria to provide a desirable objective. This provides an expanded range of acceptable values for application on 3R projects. See Section 55-4.05 for additional discussions on cross section widths.

3. Other Design Criteria. Part V contains many other details on proper geometric design techniques. These criteria are obviously applicable to new construction/reconstruction. For 3R projects, these criteria have been evaluated and a judgment has been made on their proper application to 3R projects. Unless stated otherwise in this chapter, the

criteria in other chapters apply to 3R projects and should be incorporated if practical.

4. Evaluation. The designer should evaluate available data (e.g., accident experience) when determining the geometric design of 3R projects. The following section discusses 3R project evaluation in more detail.

55-2.04 3R Project Evaluation

Sections 55-3.0 to 55-7.0 present the specific geometric design and roadside safety criteria which will be used to determine the design of 3R projects. In addition, several other factors must be considered in a 3R project, and the designer should conduct applicable evaluations as may be deemed necessary. These evaluations are discussed below.

1. Accident Experience. The historical accident data within the project limits of the 3R project will be evaluated. This is typically the most critical element of 3R project evaluation to determine the appropriate level of geometric and safety improvement. Accident data is available from the Program Development Division’s Highway Statistics Section. Section 55-8.0 further describes the Department's accident analysis procedures.

2. Existing Geometrics. The designer will normally review the as-built plans and combine this with the field review and field survey to determine the existing geometrics within the project limits. This includes lane and shoulder widths, horizontal and vertical alignment, intersection geometrics and the roadside safety design.

3. Speed Studies. The designer will make the initial determination on a case-by-case basis that a speed study may be needed for project design. The speed study should be conducted before the field review. Speed studies will be conducted by the district for INDOT projects and by the Local Public Agency or its consultant for local agency projects.

4. Physical Constraints. The physical constraints within the limits of the 3R project will often determine what geometric improvements are practical and cost-effective. These include topography, adjacent development, available right-of-way, utilities and environmental constraints (e.g., wetlands).

5. Field Review. The designer will normally conduct a thorough field review of the proposed 3R project. Other personnel should attend the field review as appropriate, including personnel from traffic, maintenance, construction, local agencies, etc. The objective of the field review should be to identify potential safety hazards and potential safety improvements to the facility.

6. <u>Pavement Condition</u>. 3R projects are sometimes programmed because of a significant deterioration of the existing pavement structure (including subbase, base and surface course). The extent of deterioration will determine the necessary level of pavement improvements. This decision will also influence the extent of practical geometric improvements. For a road to be eligible for resurfacing, the pavement should exhibit one or more of the following conditions such that a timely resurfacing is needed to prevent more serious deterioration:

   a. alligator cracking,
   b. bleeding,
   c. block (cracking),
   d. bumps (upheaval),
   e. corrugation,
   f. depression and rutting,
   g. edge cracking,
   h. longitudinal and transverse cracking,
   i. patching or utility cut,
   j. polished aggregate,
   k. potholes,
   l. slippage-cracking, and/or
   m. weathering and raveling.

   The proposed pavement improvement will be based on the design year traffic data, 10 years for resurfacing projects or 20 years for pavement replacement projects. All pavement surfaces will be designed to incorporate skid resistance.

7. <u>Structures</u>. The 3R project may include bridges and culverts within the project limits or a bridge improvement may be the 3R project. Bridges and culverts within the 3R project should be evaluated for possible structural improvements which may include:

   a. increasing the structural loading capacity;
   b. improving the roadside safety (e.g., upgrading the bridge rails);
   c. improving the horizontal and vertical alignments;
   d. widening the structure; and/or
   e. increasing the facility's hydraulic capacity.

8. <u>Geometric Design of Adjacent Highway Sections</u>. The designer should examine the geometric features and operating speeds of highway sections adjacent to the 3R project. This will include investigating whether or not any highway improvements are in the planning stages. The 3R project should provide design continuity with the adjacent sections. This involves a consideration of factors such as driver expectancy, geometric design consistency and proper transitions between sections of different geometric

designs.

9. Early Coordination for Right-of-Way Acquisition/Utilities. Field reviews and accident or speed studies may indicate the need for selective safety improvements which will require R/W purchases. R/W acquisition should be initiated as early as feasible.

   Utility relocation and accommodation is frequently encountered on 3R projects. Therefore, early coordination with utilities is essential.

10. Traffic Operations. The designer should evaluate existing traffic operations to determine where improvements can be reasonably implemented (e.g., adding turn lanes, removing signals, adding additional lanes through intersections). In addition, the designer should also review the effect construction will have on traffic operations. This may require reprogramming signals, implementing a phased construction plan, etc. Part VIII provides additional information on traffic management through construction zones.

11. Maintenance and Protection of Traffic. All 3R work will occur on existing highways. Therefore, maintenance and protection of traffic during construction will be an important consideration in 3R project development. The designer should reference Part VIII for the Department's criteria on the design of work zones for traffic accommodation.

12. Traffic Control Devices. All signing and pavement markings on 3R projects must meet the criteria in Part VII and the *Manual on Uniform Traffic Control Devices* (MUTCD). The Design Division's Specialty Projects Group or the local agency is responsible for selecting and locating the traffic control devices on the project. However, the designer should work with the proper authority to identify possible geometric and safety deficiencies which will remain in place (i.e., no improvement will be made). These may include the following:

    a. narrow bridges,
    b. horizontal and vertical curves which do not meet the 3R criteria, and
    c. roadside hazards within the obstruction free zone.

    The proper authority will then determine if additional signing, traffic control devices or delineation treatments are warranted.

13. Document the Design Process. The engineer should prepare a Preliminary Engineering Study for INDOT projects or a Safety and Design Report for LPA projects. This report should include the following:

    a. existing geometric and roadside features, traffic volumes and speeds, and accident history;

b. applicable minimum design criteria;

c. specific safety problems or concerns raised by a review of accident data, by a field inspection, or by the public;

d. design options for correcting safety problems and the cost, safety and other relevant impacts of these options;

e. proposed exceptions to applicable design criteria and the rationale to support the exceptions; and

f. the recommended design proposal.

The engineer must also prepare a list of potential design exceptions, which will need to be fully documented by the designer in accordance with Section 40-8.0.

55-3.0 TABLES OF 3R GEOMETRIC DESIGN VALUES

Figures 55-3A, 55-3B, 55-3C, 55-3D, 55-3E, 55-3F, 55-3G and 55-3H present the Department's criteria for the design of 3R non-freeway projects for both rural and urban areas.

The tables are assigned the figure numbers and are titled as follows:

55-3A	Geometric Design Criteria for Rural Arterials (3R Projects)
55-3B	Geometric Design Criteria for State Rural Collector Roads (3R Projects)
55-3C	Geometric Design Criteria for Local Agency Rural Collector Roads (3R Projects)
55-3D	Geometric Design Criteria for Rural Local Roads (3R Projects)
55-3E	Geometric Design Criteria for Multi-Lane Urban Arterials (3R Projects)
55-3F	Geometric Design Criteria for Two-Lane Urban Arterials (3R Projects)
55-3G	Geometric Design Criteria for Urban Collectors (3R Projects)
55-3H	Geometric Design Criteria for Urban Local Streets (3R Projects)

The designer should consider the following in the use of the tables.

1. <u>Project Scope of Work</u>. The Department has adopted separate criteria for the geometric design of new construction/reconstruction projects. See Chapter Fifty-three. Chapter Forty provides definitions for the non-freeway project scopes of work, which will determine when to use each set of criteria for project design.

2. Functional Classification. The selection of design values depends on the functional classification of the highway facility. This is discussed in Section 40-1.01. Functional classification maps for all public roads in the State are available from the Program Development Division.

3. Urban Design Subcategories. Within an urbanized or urban area, the selection of design values depends on the design subcategory of the facility. Separate criteria are presented for "suburban," "intermediate," and "urban" subcategories. These classifications are defined as follows:

   a. Suburban. These areas are usually located at the fringes of urbanized or small urban areas. The predominant character of the surrounding environment is usually residential, but it may include a considerable number of commercial establishments, especially strip development along a suburban arterial. There may also be a few industrial parks in suburban areas. On suburban roads and streets, drivers usually have a significant degree of freedom but, nonetheless, they must also devote some of their attention to entering and exiting vehicles. Roadside development is characterized by low to moderate density. Pedestrian activity may or may not be a significant design factor. Right-of-way is often available for roadway improvements.

      Local and collector streets in suburban areas are typically located in residential areas, but may also serve a commercial area. Posted speed limits typically range between 50 and 80 km/h. The majority of intersections will have stop or yield control, but there will be an occasional traffic signal. A typical suburban arterial will have strip commercial development and perhaps a few residential properties. Posted speed limits usually range between 60 and 90 km/h, and there will usually be a few signalized intersections along the arterial.

   b. Intermediate. As the name implies, intermediate areas fall between suburban and built-up areas. The surrounding environment may be either residential, commercial or industrial or some combination of these. On roads and streets in intermediate areas, the extent of roadside development will have a significant impact on the selected speeds of drivers. The increasing frequency of intersections is also a major control on average speeds. Pedestrian activity has now become a significant design consideration, and sidewalks and cross walks at intersections are common. The available right-of-way will often restrict the practical extent of roadway improvements.

      Local and collector streets in intermediate areas typically have posted speed limits between 50 and 70 km/h. The frequency of signalized intersections has increased substantially when compared to suburban areas. An arterial in an intermediate area will often have intensive commercial development along its roadside. Posted speed limits range between 60 and 80 km/h. These arterials typically have several signalized intersections per kilometer.

c. Built-up. These areas normally refer to the central business district within an urbanized or small urban area. The roadside development has a high density and is often commercial. However, a substantial number of roads and streets in built-up areas pass through a high-density environment (e.g. apartment complexes, row houses). Access to property is the primary function of the road network in built-up areas. Pedestrian considerations may be as important as vehicular considerations, especially at intersections. Right-of-way for roadway improvements is usually not available.

   Because of the high density of development in built-up areas, the distinction between the functional classes (local, collector or arterial) becomes less important when considering signalization and speeds. The primary distinction among the three functional classes is often the relative traffic volumes and, therefore, the number of lanes. As many as half the intersections may be signalized; posted speed limits typically range between 40 and 60 km/h.

See Section 40-1.01 for definitions of the functional classifications.

4. Rural Tables. The rural tables do not provide design criteria for sub-categories. However, there are many "rural" facilities in Indiana which pass through relatively built-up, but unincorporated, areas. In these cases, it may be inappropriate to use the criteria for rural roads and highways. The designer may, as an option, use the "suburban" criteria for that functional classification (e.g., arterials) in relatively built-up rural areas. Therefore, if the area is "urban" in character (e.g., a densely populated area with a grid-like street system), it may be appropriate to use the urban design criteria even though the facility is rural. This decision will be documented in the Preliminary Engineering Report (see Chapter Seven).

5. Cross Section Elements. The designer should realize that some of the cross section elements included in a table (e.g., sidewalk width) are not automatically warranted in the project design. The values in the tables will only apply after the decision has been made to include the element in the highway cross section.

   General Department policy is that a 3R project will not be designed with a narrower roadway width than the existing facility. See Section 55-4.05.

6. Manual Section References. These tables are intended to provide a concise listing of design values for easy use. However, the designer should review the *Manual* section references for greater insight into the design elements.

7. Footnotes. The tables include many footnotes, which are identified by a number in parentheses, e.g., (6). The information in the footnotes is critical to the proper use of the design tables.

8. Controlling Design Criteria. The 3R tables of geometric design criteria provide an asterisk to indicate controlling design criteria which, if not met, require a Level One design exception. The discussion in Section 40-8.0 on design exceptions applies equally to the geometric design of 3R projects. However, the designer will evaluate the proposed design against the criteria presented in this Chapter.

55-4.0 GEOMETRIC DESIGN

55-4.01 Design Controls

55-4.01(01) Traffic Volume Analysis

The following traffic volume controls will apply to 3R projects.

1. Design Year. Pavement resurfacing on 3R projects should be designed using a 10-year design life. Pavement replacement and all other elements of the facility should have a design life of 20 years beyond the expected construction date.

2. Level of Service (LOS). Figures 55-3A through 55-3H provide the desirable and minimum LOS criteria for 3R projects.

3. Traffic Data. The designer should obtain, from the Environment, Planning and Engineering Division, the traffic data necessary to determine the level of improvement. At a minimum, this will include current and future (10 and 20 years) ADT, DHV, percent of trucks and buses, turning movements at intersections, accident data for the most recent 3-year period, and any known future traffic impact.

4. Capacity Analysis. The analytical techniques in the *Highway Capacity Manual* will be used to conduct the capacity analysis.

55-4.01(02) Design Speed

In most cases, the existing posted or legal speed limit can be selected as the design speed on 3R projects. More specifically, the design speed should be the highest posted or legal speed limit existing generally on logical sections of the roadway consistent with the expectations for that section of roadway and future improvement plans. Logical sections will be based on land use and topography. If a road is not posted, it is desirable to perform an engineering study to determine an appropriate posted speed.

Even if the facility is posted, it may be appropriate to perform an engineering study if there is sufficient reason to believe that the existing posted speed limit may change after project completion. On a case-by-case basis, the designer may request and the District Traffic Section (or local jurisdiction) may determine that a speed study within the project limits is necessary to establish a 3R design speed.

Section 40-3.02 discusses the relationship between the project design speed and the legal speed limit. The Section also presents the legal speed limits from the Indiana statutes which apply to all public roads throughout the State.

In summary, the selection of a 3R project design speed will be one of the following:

1. the existing posted speed;

2. legal speed limit on non-posted facilities;

3. based on the results of a speed study, a revised posted speed limit or the anticipated posted limit on a currently non-posted facility; or

4. a design speed which is higher than the posted or regulatory speed limit, where deemed to be appropriate.

55-4.01(03) Adherence to Design Criteria

The discussion in Section 40-8.0 on design exceptions applies equally to the geometric design of 3R projects. However, the designer will evaluate the proposed design against the criteria presented in this Chapter. In addition, for 3R projects, a Level One design exception will be required where reconstructing a horizontal and/or vertical curve has been determined to be cost effective, but other factors would make the improvement impractical.

55-4.02 Sight Distance

The criteria presented in Chapter Forty-two on sight distance applies equally to 3R projects. However, the application of the sight distance criteria to individual highway elements (e.g., vertical curves) on a 3R project will differ from that on a new construction/reconstruction project. These are discussed at the applicable locations elsewhere in this Chapter.

55-4.03 Horizontal Alignment

Engineering judgement and/or a cost-effectiveness evaluation will ultimately reveal the need for improvements to the horizontal alignment within the 3R project. In general, improvements to the horizontal alignment should be considered if a specific problem is identified. Examples include the following:

1. a disproportionate run-off-the-road accident rate at curve sites,

2. a disproportionate number of multi-vehicle accidents at curve sites, or

3. the presence of an adverse accident history at an intersection within a horizontal curve.

The evaluation of potential improvements will include a consideration of traffic volumes, truck volumes, right-of-way and utility impacts, environmental impacts, driver expectancy, construction costs, etc.

55-4.03(01) Minimum Radius of Curve

The designer should determine the Computed Existing Design Speed (CEDS) of the curve radii within the 3R project limits. To determine the CEDS, the designer will need to determine the applicable maximum superelevation rate for the project location. For all rural highways and on all urban facilities where V > 70 km/h, an e_{max} of 8% should be used (see Figure 43-3A). For urban facilities where V ≤ 70 km/h, an e_{max} up to 6% may be used (see Figure 43-3C). Existing horizontal curves can be retained if the following conditions exist.

1. The accident data does not indicate a problem at the curve site.

2. The CEDS is no more than 25 km/h below the 3R design speed and the AADT is no greater than 750 vehicles per day.

Typically, the existing radius will be retained on curves where the above conditions are met (i.e., the curve will not need to be evaluated). However, proper signs and markings may be necessary to inform the driver of non-conforming criteria. If any of the above conditions are not met on an existing horizontal curve, then a safety benefit/cost study (B/C) should be conducted to determine if the proposed correction will be cost effective. Chapter Fifty presents the Department's procedures for conducting a benefit/cost analysis. If the B/C ratio is less than 1.0, then the existing horizontal curve may be retained. Where the B/C ratio is greater than or equal to 1.0 and it is decided to reconstruct the curve to meet the minimum radius criteria, the curve should desirably be reconstructed to meet all horizontal alignment details for new construction/reconstruction (e.g., superelevation rate, superelevation transition lengths, distribution of superelevation between tangent and curve). See Chapter Forty-three. If reconstruction is shown to be cost effective and it is decided not to undertake the work, it will be necessary to request a Level One design exception.

55-4.03(02) Superelevation

On horizontal curves where the existing radius will be retained, it may be warranted to make improvements to the superelevation. The following will apply:

1. General. The most desirable objective is to improve the horizontal curve to meet all superelevation criteria presented in Section 43-3.0.

2. Rate. Where the CEDS is less than the 3R project design speed, the superelevation rate should be increased to provide the 3R design speed, up to a maximum of 8% (rural) or 6% (urban).

   In urban areas, it may be appropriate to remove or reduce the existing superelevation at horizontal curves, if the design speed of the revised curve will equal or exceed the 3R design speed (see Section 43-3.02). This may be advantageous to better meet the roadside development, drainage conditions or to provide better operations at an at-grade intersection.

3. Transition Length Distribution. Typically, the superelevation transition length will be distributed by placing 60% - 70% on the tangent and the remainder on the horizontal curve. However, where this is not practical, a reduction to a 50% - 50% distribution is acceptable.

4. Shoulder Superelevation. Normally, the travelway/shoulder rollover break is placed at the edge of travelway on the outside of horizontal curves. However, where a paved shoulder of width through 1.2 m is used, the break should occur at the outside edge of the paved shoulder.

55-4.03(03) Reverse Curves

On 3R projects, it may be acceptable to leave reverse curves in place even if the PT and PC are coincident. To determine if improvements are warranted, existing combined reverse curves should be evaluated using the criteria in Section 43-3.07 and for each individual curve Sections 55-4.03(01) and 55-4.03(02). An evaluation of the accident history will be especially important at existing reverse curves (e.g., multi-vehicle accidents).

55-4.03(04) Broken-Back Curves

For existing broken-back curves within the limits of a 3R project, the designer should, if practical, eliminate the curves and combine them into a single, continuous horizontal curve, especially where an evaluation of the accident history indicates a problem.

55-4.03(05) Curves in Series

Frequently the alignment of a segment of a roadway consists of a series of reverse curves or curves connected by short tangents. A succession of curves may be analyzed as a unit rather than as individual curves, applying the criteria in Section 55-4.03(01).

1. The first substandard curve in a series should receive special attention because this change in alignment prepares the driver for the remaining curves in the series.

2. Any intermediate curve in a series of substandard curves that is significantly worse than the others in the series should also be analyzed individually.

2. These controlling curves can be used to determine the safety and/or other mitigation measures to apply throughout the series.

3. When improvements are considered to any curves in a series, the effect on the series of curves as a whole should be evaluated.

55-4.03(06) Shoulder Treatment

On facilities with relatively sharp horizontal curves and high truck volumes (> 500 AADT), a full-structural strength shoulder should be provided on both sides of a sharp horizontal curve in place of pavement widening. The following will apply.

1. Strengthened Length. The strengthened shoulder should be available from the beginning of the superelevation transition before the curve to the end of the transition beyond the curve.

2. Asphalt Traveled Way. The pavement structure of the strengthened shoulder will match that of the traveled way.

3. Concrete Traveled Way / Asphalt Shoulder. The Materials and Tests Division's pavement design engineer will determine the pavement structure of the strengthened shoulder.

4. Concrete Traveled Way / Concrete Shoulder. The concrete shoulder thickness will match that of the traveled way.

55-4.03(07) Horizontal Sight Distance

Section 43-4.0 presents criteria for determining if the applicable sight distance is available at a horizontal curve. If an existing longitudinal barrier interferes with the line of sight at a horizontal curve, the designer should review practical alternatives to alleviate the problem, such as eliminating the hazard that requires the barrier or offset the barrier further from the travel lane. If it is determined to leave the barrier in its existing location, it will be necessary to seek a design exception for the stopping sight distance.

55-4.03(08) Traffic Control Devices

For existing horizontal curves within a 3R project, a variety of traffic control devices may be considered to improve driver safety and comfort. These include the following:

1. signing (e.g., advance warning, chevron);
2. raised and/or standard pavement markers; and
3. reflective marker posts or delineators.

Part VII and the *MUTCD* discuss the selection and installation of traffic control devices in more detail.

55-4.04 Vertical Alignment

55-4.04(01) Grades

Figures 55-3A through 55-3H present the Department's criteria for maximum and minimum grades on 3R projects. The maximum grades are generally 1% steeper than those for new construction/reconstruction on rural arterials and 2% steeper for other facilities. Improvements to existing grades should be considered if a specific problem is identified (e.g., head-on accidents due to improper passing maneuvers, significant speed reduction for trucks).

55-4.04(02) Climbing Lanes

The warrants for climbing lanes presented in Section 44-2.0 are also applicable to 3R projects. The following will apply to the design of a climbing lane on a 3R project.

1. New. The criteria presented in Section 44-2.0 should be used.

2. Existing. Desirably, the criteria presented in Section 44-2.0 will be used. However, existing lane and shoulder widths may be retained if there is no adverse accident history that can be related to the narrower width.

55-4.04(03) Crest Vertical Curves

In many cases, existing crest vertical curves will be incorporated into 3R projects. An existing crest vertical curve can be retained if the following conditions exist.

1. there is no history of accidents related to the vertical curve (e.g., rear-end accidents);

2. the crest does not hide from view major hazards such as intersections, sharp horizontal curves or narrow bridges;

3. the K value of the existing crest vertical curve meets the criteria shown in Figure 55-4B, K Values for Crest Vertical Curves to be Retained (3R Projects), for the design speed; and

4. the design year AADT is no greater than 1500 vehicles per day.

If an existing crest vertical curve does not meet all of the criteria presented in Items 1 through 4 above (i.e., reconstruction may be warranted), a benefit/cost (B/C) study should be conducted to determine if the proposed correction will be cost effective. Chapter Fifty presents the Department's procedures for conducting a benefit/cost analysis. If the B/C ratio is less than 1.0, then the existing vertical curve can be retained. Where the B/C ratio is greater than or equal to 1.0 and it is decided to reconstruct the crest vertical curve, it should be designed using the criteria for new construction/reconstruction (see Section 44-3.0). If reconstruction is shown to be cost-effective and it is decided not to undertake the work, it will be necessary to request a Level One design exception.

55-4.04(04) Sag Vertical Curves

Section 44-3.0 presents the Department's criteria for the design of sag vertical curves for new construction/reconstruction. These criteria are based on designing the sag to allow the vehicular headlights to illuminate the pavement for a distance equal to the stopping sight distance for passenger cars. Existing sag vertical curves in 3R projects may be evaluated using the comfort criteria shown in Figure 55-4A, K-Values For Sag Vertical Curves (Comfort Criteria - 3R Projects).

The following options for evaluating sag vertical curves are shown below in order from the most desirable to the least desirable.

1. Improve the sag vertical curve to the new construction/reconstruction criteria shown in Section 44-3.0 if it is cost effective to do so.

2. Improve the sag vertical curve to be in accordance with the K-values for comfort criteria shown in Figure 55-4A. An existing sag vertical curve that can be improved by wedge and level up to 450 mm depth to be in accordance with the comfort criteria shown in Figure 55-4A, may be retained.

3. Reconstruct the sag vertical curve to an improved level, but not fully in accordance with the comfort criteria.

4. Retain the existing sag vertical curve even though it is not in accordance with the comfort criteria.

If an existing sag vertical curve does not meet the comfort criteria presented in Figure 55-4A or there is a history of accidents related to the curve (i.e., reconstruction may be warranted), a benefit/cost study should be conducted to determine if the proposed correction will be cost effective. Chapter Fifty presents the Department's procedures for conducting a benefit/cost analysis. If improvement in accordance with Section 44-3.0 is shown to be cost-effective and it is decided not to undertake the work, it will be necessary to request a Level One design exception.

55-4.04(05) Curves in Series

Frequently, the vertical alignment of a segment of a roadway consists of a series of sag and crest vertical curves or vertical curves connected by short grades. A succession of vertical curves may be analyzed as a unit rather than as individual curves, applying the criteria in Sections 55-4.04(03) and 55-4.04(04). Analysis procedures similar to Section 55-4.03(05) Items 1 through 4 should be followed:

55-4.04(06) Angle Points

It is acceptable to retain an existing "angle" point (i.e., no vertical curve) of 0.5% for crest vertical curves and 1.0% for sag vertical curves on a 3R project.

55-4.05 Cross Section Elements

Chapters Forty-five and Fifty-three present the Department's criteria for cross section elements for new construction/reconstruction projects. The tables in Section 55-3.0 present the cross section criteria for 3R projects. In general, the criteria were established as follows:

1. Upper Limit. The upper limit (or "desirable") of the range has been established as equal to the upper level for new construction criteria. On 3R projects, these still provide a desirable objective for the design of the cross section elements.

2. Lower Limit. The lower limit (or "minimum") of the range has been established by considering the minimum acceptable width for the element from an operational and safety perspective; by considering what will be available for a practical improvement on a "typical" 3R project; and by considering that, in general, it is better to improve more kilometers of roadway to a lower level than to improve fewer kilometers of roadway to a higher level. All of these considerations are consistent with the overall objectives of the Department's 3R program.

The width and/or steepness of the existing cross section should be evaluated against the criteria in the 3R tables. If the existing width and/or steepness does not meet the minimum 3R criteria, the designer should consider widening and/or flattening the element. If the decision is made to widen and/or flatten the cross section element, the designer should provide a design which at least meets the minimum 3R criteria. This will be sufficient for the majority of 3R projects. However, if practical, it may be appropriate to widen or flatten the highway elements to meet the desirable 3R criteria.

The following sections summarize the Department's 3R criteria for cross section elements.

55-4.05(01) Lane Width

3R projects should include practical improvements to the existing lane widths, if needed. Figures 55-3A through 55-3H present the Department's lane width criteria for 3R projects. In addition, the designer should consider the following travel lane widths for trucks:

1. Rural Arterials. All rural arterials in Indiana are on the National Truck Network and are to have 3.6-m travel lanes. Section 40-1.05 provides additional information on the National Truck Network in Indiana.

2. Urban Arterials. For all urban arterials that are on the National Truck Network, the right lane in each direction will be 3.6 m. For multi-lane arterials, the centerline of roadway should not be shifted to accommodate the 3.6-m right lane. The additional pavement width should be obtained by widening on the outside only.

3. Other Routes. For other routes, a minimum of 3.3-m travel lanes will be provided, if there are more than 200 trucks per day in the design year.

55-4.05(02) Shoulder Width

3R projects should include widening of the existing shoulders, if needed. Figures 55-3A through 55-3H present the Department's shoulder width criteria for 3R projects.

55-4.05(03) Roadway/Paved Width

It is general Department policy that a 3R project will not have a narrower roadway width than the existing facility.

55-4.05(04) Lane and Shoulder Cross Slope

On tangent sections, the lane and shoulder cross slopes on 3R projects should meet the criteria in Figures 55-3A through 55-3H. Shoulder cross slopes on horizontal curves should meet the criteria in Section 43-3.06. Desirably, the low side should be sloped as described in Section 43-3.06(02). At a minimum, the same cross slope on the shoulder should be kept in a tangent section.

Restoring or improving the pavement cross slope is often cost effective, resulting in the improved ride, safety, drainage and maintenance of roadway pavements.

55-4.05(05) Auxiliary Lanes

Figures 55-3A through 55-3H present the Department's criteria for lane and shoulder widths for auxiliary lanes on 3R projects. These should be provided, if practical.

55-4.05(06) Parking Lanes

For most urban projects, the designer must evaluate the demand for, or the elimination of, on-street parking. Section 45-1.04 presents the Department's policy for the removal or addition of on-street parking. Figures 55-3E through 55-3H provide the minimum and desirable parking lane widths for urban facilities.

55-4.05(07) Curbs

On 3R projects, the following will apply to the installation or retention of curbs.

1. Types. Where a project will disturb existing curbs, the curb is generally replaced in-kind.

2. Height. 3R projects may include pavement work which will not affect the lateral location of existing curbs but will affect their finished height. The designer will consider adjusting the curb height (or the pavement design) if:

   a. an analysis of the storm water flow in the gutter indicates overtopping the curb for the design parameters (e.g., design-year frequency, ponding on roadway);

   b. the existing curb is deteriorated; and/or

   c. the curb height after construction will be less than 75 mm.

3. Safety Considerations. On high-speed facilities ($V \geq 80$ km/h), existing curbs should be removed for safety reasons, if they are not needed for drainage.

55-4.05(08) Sidewalks

Where a 3R project will disturb existing sidewalks, the sidewalk is typically reconstructed or replaced in-kind, including curb ramps. Where sidewalks do not currently exist, the need for sidewalks will be determined on a case-by-case basis as discussed in Section 45-1.06. Sidewalk construction and maintenance funding are dependent upon the project location. The following will apply.

1. Towns/Rural Areas. New sidewalks constructed in towns and in rural areas outside of city limits may be funded with State and Federal funds. This includes all the costs for grading, construction and right-of-way.

2. City Limits. For sidewalks constructed within the corporate city limits using Federal funds, INDOT may elect to participate in the cost of constructing the sidewalk. For non-Federally funded projects, the city will be responsible for the costs of constructing the sidewalk. A reimbursement agreement will be required between the Department and the city prior to the project letting. The State will be responsible for the cost of right-of-way and any grading required specifically for the sidewalk.

3. Bridges. Regardless of location, the total cost for sidewalks on bridges may be funded with State and Federal funds.

Curb ramps will be provided at all pedestrian crosswalks within the project limits. See Section 51-1.0 and the INDOT *Standard Drawings* for additional information on handicapped accessibility requirements.

55-4.05(09) Median Width

The following will apply to medians on 3R projects.

1. Existing Medians. An existing multi-lane, divided highway (non-freeway) may be improved as a 3R project. If so, the existing median width will normally be retained.

2. Flush Medians. The typical width for a flush median on an urban street ranges from 1.2 m to 4.8 m. If the median width is 4.8 m or less, the designer should consider using a continuous raised corrugated median. The INDOT *Standard Drawings* provide additional details on the design of corrugated medians. For additional information on flush medians, see Section 45-2.02.

3. Raised Medians. Desirably, the width of a raised median should be 2.4 m. This assumes a minimum 1.2-m raised island with 0.6-m curb offsets on each side adjacent to the through travel lanes. In restricted locations, the minimum median width may be 0.6 m. This assumes a raised island of 0.6 m with sloping curbs and 0.0-m curb offsets. The minimum median width with vertical curbs is 1.2 m based on 0.3-m minimum curb offsets. For additional information on raised medians, see Section 45-2.02. These widths apply to both existing and proposed raised medians within 3R projects.

55-4.05(10) Fill/Cut Slopes

The following will apply to fill and cut slopes within the limits of a 3R project.

1. No Roadway Widening. Existing 2:1 or flatter fill and cut slopes will typically be retained.

2. Roadway Widening. If the lane and/or shoulders are widened as part of the 3R project, this will produce a steeper fill slope or ditch foreslope (assuming the toe of fill slope or toe of backslope remains in the same location). Desirably, the designer will modify the roadside design to provide a configuration which is the same as or flatter than the roadside cross section before the 3R project. At a minimum, the following will apply:

   a. Embankment slopes. The use of 3:1 slopes should be considered for most 3R projects. However, an effort should be made to construct up to a 6:1 slope at least within the obstruction-free zone where 6:1 or flatter slopes already exist, or where the length of the improvement is greater than 0.8 km. See Section 55-5.0 for obstruction-free zone dimensions. If steeper slopes are required, 2.5:1 slopes should be considered before implementing 2:1 slopes. Slopes behind guardrail at the corners of bridges should not be routinely steepened to 2:1 even though the slope may be completely protected by the guardrail. Locations and situations that may warrant 2:1 slopes are as follows:

      (1) Roadway widening that encroaches into a wetland;

      (2) Areas with restrictive or very costly right of way; or

      (3) Slopes at ends of large culverts, bridge spillslopes, or other locations where it is desirable to protect slopes with riprap.

      Where 2:1 slopes are specified they should be protected with erosion control blankets. Capping soils suitable for growing vegetation should be provided.

The use of 2:1 slopes on local agency projects will be at the discretion of the local agency.

Each location must be analyzed individually and judgment used in selecting the slope rate.

b. Ditches. If right of way is available, the existing ditch line should be moved and slopes flattened as much as practical. Drainage ditches in the obstruction free zone should be regraded as much as practical to make them traversable for errant vehicles. See Section 49-3.02 for information on traversable ditches.

c. Guardrail. Consideration should be given to obtaining a 3:1 slope in fills to minimize the need for guardrail. Embankments should desirably be widened when guardrail will be installed as required by Section 55-5.0.

d. Embankment Stability. In all cases, stable embankment material must be used and placed in accordance with the INDOT *Standard Specifications*. Sod or other stabilizing materials or methods should be provided wherever erosion may be considered a problem.

3. Roadside Safety. Upgrading the roadside safety of the highway is often a major objective of the 3R project. On all 3R projects, the designer should consider the safety benefits of flattening fill and cut slopes to eliminate guardrail and, at a minimum, to meet the criteria presented in Item 2 above. An evaluation of run-off-the-road accidents will assist in the assessment (see Chapter Fifty). See Section 55-5.0 for more information regarding roadside safety criteria for 3R projects.

55-4.05(11) Right of Way

As indicated in the basic definition of a 3R project, only minimal right-of-way acquisition will usually be required (e.g., lane and shoulder widening). Occasionally, more extensive right-of-way involvement may be appropriate if, for example, a horizontal curve is flattened. Wherever practical, additional right-of-way should be secured to allow cost-effective geometric and roadside safety improvements.

55-4.06 Intersections At-Grade

Chapter Forty-six provides criteria for the detailed design of intersections at-grade for new construction/reconstruction. Wherever practical, these criteria apply to 3R projects and should be implemented. The following sections indicate areas where modifications to the intersection design criteria may be made for 3R projects.

55-4.06(01) General Design Controls

The criteria presented in Section 46-1.0 for intersection alignment, profile, design vehicle selection, etc., also apply to 3R projects, except where noted in the following:

1. Intersection Alignment. Preferably, the angle of intersection should be within 20º of perpendicular. Existing intersections may be retained with angles up to 30º if there are no operational problems or adverse accident history.

2. Y Intersections. On 3R projects, all existing Y intersections should be converted to T intersections.

3. Design Vehicle Selection. Existing intersections should be checked to determine if the suggested design vehicle criteria in Figure 46-1E can be accommodated using the criteria in Section 55-4.06(02) for turning radii. Intersections which will not accommodate the minimum design vehicle should be considered for reconstruction.

55-4.06(02) Turning Radii

Unless alerted by District personnel or where there is physical evidence of problems at an intersection (e.g., tire tracks over curbs, broken curbs, scraped utility poles), it will probably not be necessary to reconstruct the intersection to improve the turning radii design as part of the 3R project. However, once it has been determined to upgrade the intersection, the designer should desirably meet the criteria presented in Section 46-2.0. In urban areas, however, space limitations and existing curb radii have a significant impact on selecting a practical design for right-turning vehicles. The designer should consider the following when determining the appropriate right-turn treatment for urban intersections on 3R projects.

1. Inside Clearance. The minimum inside clearance of the selected design vehicle may be zero; i.e., the inside tire track may “touch” the curb line or pavement edge.

2. Encroachment. Once a decision has been made to improve the intersection, the selected design vehicle should meet the encroachment criteria as discussed in Section 46-2.0. Under restricted conditions, an additional 0.3-m encroachment may be allowed for each functional classification.

3. Swept Width. The designer should review the existing or redesigned intersection with the turning templates to ensure that there are not obstacles in the swept path of the turning design vehicle.

4. Minor Intersections. At intersections with at least one leg considered a minor road, school buses, garbage trucks and fire trucks should be able to physically make the turn onto the minor street.

As a general summary of acceptable existing turning radii on 3R projects, the following will apply.

1. Passenger Cars. Simple radii of 4.5 m - 7.5 m are adequate for passenger vehicles. These radii may be retained on 3R projects on existing streets at the locations as follows:

   a. intersections with minor roads where very few trucks will be turning;

   b. intersections where the encroachment of SU and semitrailer vehicles onto adjacent lanes is tolerable; and

   c. intersections where a parking lane is present, and it is restricted a sufficient distance from the intersection, and is used as a parking lane throughout the day.

2. SU Vehicles. Existing simple radii of 9.0 m or simple radii with tapers (for the SU design vehicle) may be retained.

3. Semi-Trailers. At intersections where semitrailer combinations and buses turn frequently, an existing simple radius of 12.2 m or more may be retained. Preferably, the designer will use a radius with taper offsets for the selected design vehicle.

55-4.06(03) Turn Lanes

Section 46-4.0 presents warrants for right- and left-turn lanes and design details for auxiliary turn lanes. These should be met if practical on 3R projects. However, the criteria for new construction/reconstruction may be impractical because of restricted site conditions. In general, the designer will provide the best design practical for the field conditions. Following are several specific examples of acceptable design criteria for auxiliary turn lanes on 3R projects.

1. Shoulders. Existing paved shoulders of sufficient width and pavement strength may be striped to indicate a separate right-turn lane at an intersection. If so, it may be necessary to rebuild and/or re-design the curb return to accommodate the selected design vehicle.

2. Reduced Travel Lane Width. In urban areas, it will be acceptable to reduce the width(s) of the approaching travel lane(s) at signalized intersections to provide a reasonable width for turn lanes. However, travel lanes should be at least 3.0-m wide at the intersection and may warrant wider lanes if truck traffic turns must be accommodated.

3. Turn-Lane Widths. As indicated in Figures 55-3A through 55-3H, turn-lane widths on 3R projects may be narrower than those for new construction/ reconstruction projects.

4. Length. The lengths for turn lanes should desirably include the components for taper, deceleration and storage as presented in Section 46-4.02. These criteria may be especially impractical on 3R projects, particularly the length for the vehicular deceleration component. However, the minimum turn-lane lengths in Section 46-4.02 apply to 3R projects.

55-4.06(04) Intersection Sight Distance (ISD)

Intersection sight distance should be in accordance with the criteria shown in Section 46-10.0. The location of the eye may be 4.4 m from the edge of the travel lane with respect to stop-controlled intersections.

55-5.0 ROADSIDE SAFETY

Many of the improvements made on 3R projects will have a positive effect on highway safety. In addition, 3R projects afford an opportunity to further enhance highway safety by accomplishing needed safety improvements at high hazard locations and cost effective adjustments or modifications to high hazard features. Section 49-10.0 provides information on how to use ROADSIDE, a computer software program which may be used to determine if roadside safety improvements are cost effective. The following discussion offers roadside safety criteria which apply specifically to 3R projects.

55-5.01 Analysis of Accident Data

The designer should obtain the accident history for the three-year calendar period immediately prior to the year in which project design is initiated. The data may be summarized on the form included in Section 55-8.0 or in any other convenient format.

The data should be analyzed to determine if there are any correctable accident patterns at a particular spot (300-m minimum length), intersection or section of the highway. If a pattern exists, probable causes should be identified and appropriate safety enhancements included in the project. All intersections and sections which have an average of four or more accidents per year for the three-year period should be analyzed in accordance with the guidelines described in Section 55-8.0. This will require obtaining copies of the accident reports for these locations and possibly the preparation of collision diagrams. A short discussion of the probable causes and corrective action to be incorporated into the project for each section and intersection should be included in the Preliminary Engineering Study for INDOT projects or in the Safety and Design Report for Local Public Agency projects. Some of these sections and intersections may be experiencing the type of accidents that are correctable by highway improvements. In other cases, the analysis may reveal that there is no apparent safety enhancement that can be included in the project. When this situation exists, a short discussion should be included in the Study/Report to document that these sections and/or intersections were reviewed.

A list of high accident locations has been developed from the INDOT Safety Improvement Program. This list is available from the Program Development Division. All 3R projects should be coordinated with proposed safety projects, because the implementation of projects in one area may influence priorities in another. Safety and 3R projects should be accomplished at the same time as practical.

55-5.02 Obstruction Free Zone

The obstruction free zone is defined as the roadside area next to the travelway which should be free from hazards and obstructions. This is not the same as the clear zone and these two terms are not interchangeable. Obstacles within the obstruction free zone limits should be removed, made breakaway or shielded with guardrail. The obstruction free zone values given below are minimums and should be extended where accident experience indicates a wider zone would further enhance safety. The clear zones presented in Section 49-2.0 should be provided, if practical. The designer should review Section 49-2.0 for additional information on clear zones. The following obstruction free zones apply to 3R projects.

1. Rural and Urban Arterials With Shoulders. Where the design speed is 80 km/h or greater and the design ADT is over 1500, the minimum obstruction free zone is 6.0 m from the edge of the through traffic lanes or to the right-of-way line, whichever is less. In all other cases, the minimum obstruction free zone from the edge of through traffic lanes is 3.0 m plus the usable shoulder width provided, or to the right-of-way line, whichever is less.

2. Rural and Urban Collectors With Shoulders. Where the design speed is 80 km/h or greater and the design ADT is over 1500, the minimum obstruction free zone from the edge of the through traffic lanes is 3.0 m plus the usable shoulder width provided, or to the right-of-way line, whichever is less. In all other cases, the minimum obstruction free zone from the edge of through traffic lanes is 2.0 m, plus the usable shoulder width provided, or to the right-of-

way line, whichever is less.

The following example illustrates the computation of the obstruction free zone.

Given:	
Design Criteria	3R
Design Functional Classification	Local Agency Collector
Rural/Urban	Rural
V	90 km/h
AADT	1200
Lane Width	3.3 m
Usable Shoulder Width	1.8 m
Paved Shoulder Width	1.2 m

The minimum obstruction free zone is 2.0 m plus the usable shoulder width provided. Therefore the minimum obstruction free zone is 3.8 m from the edge of the through lane.

3. Rural and Urban Local Roads and Streets With Shoulders. The minimum obstruction free zone from the edge of the through traffic lane is 2.0 m plus the usable shoulder width provided, or to the right-of-way line, whichever is less.

4. Curbed Roadways. Where curbs are 150 mm or higher and the posted speed limit is less than 80 km/h, the minimum obstruction free zone from the face of the curb should be 0.5 m. However, for traffic signal supports the minimum obstruction free zone should be 0.8 m. Where the curbs are less than 150 mm in height or the posted speed limit is 80 km/h or greater regardless of curb height, the minimum obstruction free zone will be the same as defined in Items 1, 2, or 3 above.

5. Appurtenance-Free Area. Roadways for all functional classifications should have a 0.5-m appurtenance-free area from the face of curb or from the edge of the travel lane if there is no curb. For traffic signal supports, a 0.8-m clearance should be provided. The appurtenance-free area is defined as a space in which nothing, including breakaway safety appurtenances, should protrude above the paved or earth surface (see Figure 55-5A, Appurtenance Free Zone). The objective is to provide a clear area adjacent to the roadway in which nothing will interfere with extended side-mirrors on trucks, with the opening of vehicular doors, etc.

6. On-Street Parking. The following obstruction-free zone requirements will apply to facilities with on-street parking.

   a. Continuous 24-Hour Parking. No obstruction-free zone is required on facilities where there is continuous 24-hour parking, except that the appurtenance-free area as shown in Figure 55-5A should be provided from the face of the curb or edge of the parking lane if there is no curb.

b. Parking Lane Used as a Travel Lane. The obstruction-free zone should be determined assuming the edge of the parking lane as the right edge of the farthest right travel lane.

55-5.03 Treatment of Obstructions

Obstructions and non-traversable hazards within the obstruction free zone should be, in order of preference, as follows:

1. removed or redesigned so that they can be safely traversed,

2. relocated outside of the obstruction free zone to a point where they are less likely to be hit,

3. made breakaway to reduce impact severity,

4. shielded with a traffic barrier or impact attenuator, or

5. delineated if the above treatments are not practical.

55-5.03(01) Application

The designer should eliminate or modify the following hazards, according to the above treatments, if they are within the obstruction free zone:

1. Tree Removal. Trees maturing to a diameter of 100 mm or more should be removed from the obstruction free zone, unless shielded by a protective device required for other purposes. Trees on backslopes may generally remain if they are unlikely to be impacted by errant vehicles.

2. Obstructions. Obstructions within the obstruction free zone, such as rough rock cuts, boulders, headwalls, foundations, etc., with projections that extend more than 100 mm above the ground line should be removed, relocated, made breakaway or shielded with guardrail as appropriate. A rough rock cut is one that presents a potential vehicular snagging problem.

3. Sign and Light Supports. Sign posts and light poles to remain within the obstruction free zone will be made breakaway. In urban areas where pedestrian traffic is prevalent, breakaway light supports should not be used. However, these supports should, as a

minimum, be offset beyond the obstruction free zone value as presented in Section 55-5.02 or desirably behind the sidewalk. In other areas where pedestrian traffic is prevalent, the use of breakaway supports will be considered on a case-by-case basis by the field review team. Section 49-3.06 provides additional information on the treatment of signing and lighting supports which is also appropriate within the obstruction free zone.

4. Traffic Signals. Traffic signal supports should be placed to provide the obstruction-free zone through the area where the traffic signal supports are located. However, the following exceptions will apply:

   a. Channelized Islands. Installation of signal supports in channelizing islands should be avoided, if practical, however, if a signal support must be located in a channelizing island, a minimum clearance of 9.0 m should be provided from all travel lanes (including turn lanes) in rural areas and in urban areas where the posted speed is greater than 70 km/h. In urban areas where the island is bordered by a vertical curb and the posted speed is 70 km/h or less, a minimum clearance of 3.0 m should be provided from all travel lanes (including turn lanes).

   b. Non-Curbed Facilities (Posted Speeds $\geq$ 80 km/h and ADT > 1500). Where conflicts exist such that the placement of the signal supports outside of the obstruction-free zone is impractical (e.g., conflicts with buried or utility cables), the signal supports should be located at least 3.0 m beyond the outside edge of the shoulder.

   c. Non-Curbed Facilities (Posted Speeds < 80 km/h or ADT $\leq$ 1500). Where conflicts exist such that the placement of the signal supports outside of the obstruction-free zone is impractical (e.g., conflicts with buried or utility cables), the signal supports should be located at least 2.0 m beyond the outside edge of the shoulder.

5. Culverts. Culvert ends are considered to be within the obstruction free zone if the point at which the top of the culvert protrudes from the slope is within the obstruction free zone. Section 55-5.03(02) provides additional information for the treatment of drainage structures on 3R projects.

6. Transverse Slopes on Side Roads and Private Drives. Steep transverse slopes on side roads and private entrances should be considered for flattening, if practical. Desirably these slopes should be 6:1 or flatter, but in no case should they be steeper than 4:1. Transverse slopes on median crossovers will be 10:1 or flatter.

7. Curbs. Curbs should generally be removed on rural highways where posted speeds are greater than 70 km/h. The proper placement of traffic control devices must be considered in reviewing the removal of corner island curbs where such devices are located. This item is not intended to cover divisional (channelizing) islands separating two-way traffic or curbs at

the edge of shoulder for drainage. In the latter two cases, sloping curbs should be used on highways with posted speeds greater than 70 km/h.

Curbs higher than 100 mm should not be used in conjunction with guardrail. The face of curbs, used in conjunction with guardrail, should desirably be behind the face of the rail. If this cannot be achieved, the face of the curb may be located flush with the face of the rail.

8. Utility Poles. Utility poles within the obstruction free zone which are not owned by INDOT or local highway agencies often constitute a significant hazard and should be removed or relocated. Utility companies should be requested to relocate utility poles that are located in high vulnerability areas such as channelizing islands, or where the accident history indicates there has been a utility pole accident problem. The field review team, based on their judgment, will determine where such work is warranted.

9. Mailbox Supports. All new mailbox installations should be placed in accordance with the INDOT *Standard Drawings*, INDOT *Standard Specifications* and Section 51-11.0.

10. Non-Traversable Hazards. Fill slopes steeper than 1:1 with a height greater than 0.6 m within the obstruction-free zone should be flattened to the extent practical. If any part of a drainage ditch appears within the obstruction-free zone, its cross section should comply with the criteria described in Section 49-3.02.

11. Drainage Ditches. A ditch is considered inside the obstruction free zone if the near side of the ditch bottom is within the obstruction free zone.

    If a ditch is located inside the obstruction free zone, the ditch should be traversable. See Section 49-3.02. If the ditch it is not traversable, a Level Two design exception is required. If a traversable ditch is not provided, a 1.2-m wide bottom should be provided for the ditch with the backslope as flat as practicable.

    If a ditch is located outside the obstruction free zone, no design exception is required regardless of which of the following alternates (ranked in order of preference from top to bottom) is used.

    a. The ditch should be made traversable. Although it is not mandatory to provide a traversable ditch section, there are some situations where this can be accomplished but should only be pursued in situations where the gentler section does not significantly affect the right-of-way needs.

    b. A 1.2-m flat-bottom ditch should be provided.

    c. A flat-bottom ditch less than 1.2 m wide should be provided.

d. A "V" ditch should be provided.

With respect to Items 2, 3, and 4, the backslopes should be designed to be as flat as practicable.

12. Other Hazards. The designer should review Section 49-3.0 to determine the appropriate treatment for additional hazards not discussed above, such as bridge piers or bridge railing ends.

55-5.03(02) Drainage Structures

In general, no mainline cross culverts that are 1500 mm or less in diameter and pipe arches 2100 mm x 1450 mm and smaller should be extended to locate the inlet/outlet ends outside the obstruction-free zone. This practice often introduces undesirable embankment slope discontinuities.

All mainline cross culverts 1500 mm or less in diameter and pipe arches 2100 mm x 1450 mm and smaller, which are terminated within the obstruction free zone, should be treated as follows:

1. Standard metal culvert end sections should be used within the obstruction free zone on circular culverts up through 750-mm diameter and on pipe arch culverts up through 900 mm x 600 mm which are skewed 10 degrees or less, from the perpendicular, towards the direction of approaching traffic.

2. Grated end sections should be used on all circular culverts that are 900 mm through 1500 mm and pipe arch culverts that are 1100 mm x 675 mm through 2100 mm x 1450 mm.

3. Grated end sections should be used on all culverts which are skewed more than 10 degrees, from the perpendicular, towards the direction of approaching traffic.

4. If the culvert end for 1675 mm or larger culverts is within the obstruction-free zone, guardrail should typically be provided. If the culvert end falls outside the obstruction-free zone, the designer should use engineering judgment to determine if it is desirable to protect the errant motorist from the culvert end with guardrail. If there is inadequate cover over the culvert to drive the guardrail posts, it will be necessary to use the detail for guardrail over low-fill culverts as shown in Section 49-5.03 and the INDOT *Standard Drawings.*

5. If the point at which the top of the box culvert or three-sided structure protrudes from the slope is within the obstruction free zone, guardrail should typically be provided. Otherwise, Figure 55-5A$_1$, Clear Zone / Guardrail at Culverts, should be used to

determine the appropriate treatment.

All 300-mm and 375-mm diameter culverts that are parallel to the mainline and inside the obstruction free zone, or within a 18-m wide or less median, require standard metal or concrete end sections. All culverts over 375 mm in diameter that are parallel to the mainline and inside the obstruction free zone, or within a 18-m wide or less median, require grated end sections.

55-5.04 Roadside Barriers

During the design of a 3R project, all existing safety appurtenances should be examined to determine if they meet the latest safety performance and design criteria. This includes guardrail, median barriers, impact attenuators, sign supports, luminaire supports and bridge railings. Normally, substandard safety appurtenances will be upgraded to meet the most recent criteria. Chapter Forty-nine and the INDOT *Standard Drawings* present the Department's criteria for the layout and design of safety appurtenances. For the application of guardrail on 3R projects, the designer should review the following sections.

55-5.04(01) Existing Guardrail

Existing guardrail installations should be removed when such installations do not meet the location warrants provided in Section 49-4.0 or when the obstacle(s) or hazard can be removed at a cost less than guardrail upgrading plus estimated guardrail maintenance costs over the life of the installation. If existing guardrail is still warranted, it should be upgraded according to the following criteria:

1. Guardrail Components. All guardrail and end treatments which do not meet current criteria presented in Section 49-4.0 and the INDOT *Standard Drawings* should be replaced or upgraded to the current criteria. However, existing W-beam guardrail with U-channel rub rail may be retained. Existing buried end sections may remain on 2-lane local-agency highways if the design year AADT is less than 1000.

2. Transitions. Substandard guardrail transitions to bridge piers and other obstructions should be upgraded or replaced to meet the current criteria in Section 49-4.0 and the INDOT *Standard Drawings*.

3. Height. Guardrail less than 685 mm in height, at the top of the rail element, should be raised using adjustable blockouts, reset or replaced as appropriate.

4. Lateral Clearance. Reduced post spacing should be provided when the distance between guardrail and an obstruction is less than the required deflection distances as shown in Section

49-5.0.

5. Gaps. All gaps of 60 m or less between guardrail runs should be closed, if practical.

6. Length of Need. All guardrail runs should meet the length of need requirements presented in Section 49-5.0 including those pertaining to clear zones. The obstruction free zones listed in Section 55-5.02 may not be used as clear zones in determining length of need requirements. The clear zones for computing the length of need are provided in Section 49-2.01. The length of need may be modified if deemed appropriate by the field review team members. See Figure 55-5B, Runout Length, L_R, m, for Restrictive Conditions.

55-5.04(02) New Guardrail Installations

New guardrail should be installed as follows:

1. where it is not practical to eliminate an obstacle from the obstruction free zone as defined in Section 55-5.03,

2. where the guardrail is judged less hazardous than the object,

3. at all approaches to bridge railings, and
4. where in the opinion of the field review team, there is an extreme hazard which obviously warrants guardrail.

All new installations of guardrail on 3R projects will meet the criteria presented in Chapter Forty-nine and the INDOT *Standard Drawings*, except as follows:

1. Length of Need. The length of need may be modified by the field review team if deemed absolutely necessary.

2. Shoulder/Guardrail. The desirable guardrail offset is 0.6 m from the effective usable shoulder width, or the shy line offset distance, whichever is larger. See Figure 49-5F for shy line offsets. The minimum guardrail offset distance is 1.2 m from the edge of travelway.

   Generally, a guardrail offset distance of 0.6 m from the effective usable shoulder width is used. In restrictive situations depending on functional classification, a guardrail offset may be 0 m from the effective usable shoulder width.

3. Post Embedment and Earth Backup. The desirable distance from the face of guardrail to the shoulder break point is 1.0 m. In restrictive situations, the distance from the face of guardrail

to the shoulder break point may be 0.0 m.

4. End Treatments. The type I end treatment may not be used on INDOT routes, or other facilities which have a design year traffic volume of 1000 AADT or greater. Section 49-5.04 provides additional information on end treatments which may be used on high-volume, high-speed roads.

5. Length of Need for Restrictive Conditions. Where restrictive conditions warrant, the following table should be used to determine the Runout Length, L_R.

One example of a restrictive condition is the close proximity of a driveway to the end of a bridge, which cannot be relocated any farther from the bridge.

If it is decided at the field check to shorten the length of guardrail needed, the field check minutes must document the decision.

55-6.0 BRIDGES

55-6.01 General

Figures 55-3A through 55-3H provide the Department's criteria for structural capacity and widths for new and reconstructed bridges within a 3R project and for existing bridges to remain in place within the limits of a 3R project. Existing bridges may remain in place if they meet, or are upgraded to meet, the structural and geometric requirements presented in Figurles 55-3A through 55-3H and in Section 55-6.02. Upgrading a bridge to meet the criteria should only be undertaken if an engineering and economic analysis shows that the upgrading is cost effective. Some of the items that should be considered in such an analysis include the following:

1. remaining service life,
2. sufficiency rating,
3. traffic volumes,
4. clear roadway width,
5. snow storage,
6. farm equipment clearances,
7. design speed, and
8. accident records.

If it is decided that a bridge should be replaced or have major reconstruction (e.g., replacing superstructure, widening superstructure or widening substructure), the design will be done in accordance with current AASHTO criteria and load carrying capacity (see Part VI). The only exception is that the bridge width criteria presented in Section 55-6.03 may be used if the most likely level of future (20 to 30 years) highway improvement on the approaches and adjacent road sections will be to 3R criteria (i.e., the road will not be reconstructed in the foreseeable future). Reasons for determining the use of the widths in Section 55-6.03 must be documented in the Preliminary Engineering Study for INDOT projects or in the Safety and Design Report for Local Public Agency projects. It should be noted that the widths presented in Section 55-6.03 may also be used on bridges which are a part of a 3R project, isolated bridges on existing alignment, and isolated bridges where the alignment has been changed. In the latter case, the minor roadway realignment may be constructed to 3R criteria as presented in this Chapter.

55-6.02 Bridges To Remain In Place

If an existing bridge is structurally sound and if it meets the Department's design loading for structural capacity, it is generally unlikely to be economical to improve the geometrics of the bridge. If an existing bridge does not meet the following, it should be evaluated for upgrading or replacing (see Section 55-6.01). The following will apply to existing bridges within the limits of a 3R project.

1. Width. The width of the existing bridge should be evaluated against the criteria in Figures 55-3A through 55-3H.

2. Structural Capacity. The structural capacity of the existing bridge should be evaluated against the criteria in Figures 55-3A through 55-3H.

3. Vertical Clearance. Existing structures should provide at least a 4.30-m vertical clearance. If the 4.30-m vertical clearance is not available, consideration should be given to increasing the vertical clearance either as part of the 3R project or as a separate project. Any modifications should desirably provide for a clearance of 4.45 m. If it is necessary to retain a vertical clearance of less than 4.30 m, then a design exception request will need to be processed in accordance with Section 40-7.0. Low clearance signage is required on all bridges with less than a 4.45-m vertical clearance.

4. Bridge Railings. Only existing bridge railings that have been proven to be acceptable through crash testing or that meet the structural and geometric requirements of the current AASHTO *Standard Specification for Highway Bridges* may be retained. All new bridge railing installations will meet the Department's current criteria (see Part VI). Consideration should be given to widening the bridge at the same time the railing is replaced to achieve the full approach travelway and shoulder width.

   Design exceptions to this criterion will only be considered if all of the following conditions are met.

   a. the project is a rehabilitation project on a non-NHS route;

b. the existing bridge railing and approach guardrail are considered to be satisfactory (i.e., they do not need to be replaced);

c. the accident history does not indicate that there may be a problem;

d. the design year AADT is less than 400 vpd; and

e. the design speed is less than 60 km/h.

5. Narrow Bridges. All bridges which are narrower than the approach roadway width (and will not be widened) should be evaluated for special narrow bridge treatments. At a minimum, the signing and pavement markings must meet the criteria of the INDOT *Standard Drawings*. In addition, NCHRP 203 *Safety at Narrow Bridge Sites* provides criteria specifically for narrow bridges (e.g., special pavement markings).

55-6.03 Bridges Requiring Replacement or Major Reconstruction

The new bridge widths in Figures 55-3A through 55-3H are intended to be applied only to bridges where it has been determined that the 3R criteria is the most probable level of future (20 to 30 years) highway improvement on the approaches and adjacent roadway sections. If the expected improvement will be reconstruction, then the bridge widths in Tables 53-2 through 53-9 should be used. The 3R bridge work can include rehabilitation using structurally sound elements of existing bridges, complete bridge replacement on existing alignment, and replacement bridges on short relocations. These bridge widths are minimums, and greater widths should be used if deemed appropriate.

The minimum widths for these bridges are the sum of the lane widths and shoulder widths (or curb offset widths) shown in Figures 55-3A through 55-3H for the functional classification of the road upon which the bridge is located plus the offset distance for guardrail. The intent is to carry the 3R roadway cross section across the bridge. The minimum bridge deck width will be 9.4 m on the State Highway System in rural areas.

Future bridge deck rehabilitation work may necessitate a greater minimum bridge width than indicated above. Normally, the deck width must be at least 9.0 m if bridge deck rehabilitation is to be done one-half width at a time. However, on some local roads and streets, this 9.0-m minimum width will not be necessary if it is determined that it will be practical to close the bridge and detour traffic when such work becomes necessary.

The use of the road by agricultural equipment may also necessitate the use of bridge widths greater than the minimum prescribed herein. The need for greater bridge widths to accommodate this equipment will be determined on a project-by-project basis. Approach guardrail should be offset to the same position as the bridge rail from the edge of the traveled way, if bridge widths greater than the approach roadway (traveled way plus shoulders) are used.

These bridges must be designed to comply with all AASHTO load carrying capacity standards provided in Figures 55-3A through 55-3H. All new bridge railing installations must meet the Department's current criteria (see Part VI). The waterway openings will be determined in accordance with all applicable permit requirements.

55-7.0 MISCELLANEOUS DESIGN ELEMENTS

55-7.01 Traffic Control Devices

All signs, signals and pavement markings on the mainline, and intersection related traffic control devices on crossroad approaches, must conform to Part VII and the MUTCD. It should be noted that it is the Department's practice to install centerline and edgeline pavement markings and no-passing zone pennants and regulatory signs on all roads. In some cases, it may be necessary to carry pavement markings and related signs beyond the project limits to end them at some logical termini (e.g., major intersections, end of a no-passing zone). Centerlines and edgelines do not have to be installed on those roads where these devices are not warranted based on the opinion of the field review team. For example, pavement markings would not normally be warranted on a bridge replacement project on a road that does not have pavement markings.

55-7.02 Railroad Crossing Warning Devices and Surfaces

The adequacy of existing warning devices and crossing surfaces should be investigated if the 3R project includes an at-grade railroad crossing within the project limits. Railroad grade crossing surfaces should provide for a reasonably smooth ride and have a width equal to at least the approach traveled way and shoulders plus 0.3 m on each side. All railroad crossings which do not meet the above surface requirements should be upgraded concurrent with the 3R work. If an active warning device installation or upgrading is determined to be necessary, it should also be done concurrent with the 3R project. For more information on upgrading at-grade railroad crossings, see Chapters Eleven and Forty-seven.

55-7.03 Trimming of Brush and Trees

Trees and brush should be trimmed, as necessary, to obtain the required stopping, intersection and/or railroad crossing sight distances and sign visibility.

55-7.04 Encroachments

All encroachments within the right-of-way should be treated according to the encroachment procedures contained in Chapter Eighty-six.

55-8.0 GUIDELINES FOR ANALYZING ACCIDENT DATA ON 3R PROJECTS

A primary measure of the safety of an existing highway is its accident history. Once a highway location has been proposed for a 3R project, accident data will need to be collected and analyzed to determine the relative safety of the facility and to identify and describe the accident characteristics or patterns that have occurred. Safety enhancements to alleviate safety deficiencies can be more readily identified from this analysis, and the extent of minimum safety enhancement can be determined.

55-8.01 Accident Analysis Procedures

55-8.01(01) Responsibilities

When conducting an accident analysis the designer will need to perform the following:

1. be prepared to spend sufficient time conducting the accident study;
2. study individual accident reports;
3. check project termini, often at some logical point such as an intersection, to ensure accident information is considered just beyond the project termini;
4. relate accident data to field conditions, preferably when there are only a limited number of accidents reported. The data should be reviewed in the field or on the videolog; and
5. discuss the project with maintenance personnel. Many single-vehicle or non-injurious accidents go unreported and yet are strong indicators of potentially hazardous situations.

55-8.01(02) Accident Summaries

Accident analysis study procedures involve determining the significance of the accident history and the development of summaries of the accident characteristics within the 3R project termini. The project's accident summaries are used to detect abnormal accident trends or patterns and to distinguish between correctable and non-correctable accident experience. Analysis of these summaries is needed to identify probable safety deficiencies of the existing facility.

When conducting the accident analysis, the designer should consider the following:

1. Time Period. The required time period for the collection of the accident history is three years. In selecting the period, the accident date should represent reasonably current information because related factors such as traffic volumes, pavement condition and other site-related data may vary with time. Likewise, care should be taken to ensure that the past changes in the character of the facility (e.g., physical changes, roadside development) are accounted for when evaluating the accident activity.

2. Vehicle Direction. The accident data needs to be examined to determine direction the vehicles were traveling.

3. Location. Accident data should be examined with respect to location. Accidents occurring within an intersection area should be separated from those occurring outside the area of influence of the intersection. In addition, similar accident types occurring in differing situations should be separated. For example, left-turn accidents into a driveway should not be included with left-turn accidents at an intersection.

4. Accident Rate. The accident data should be examined to determine the number of accidents and the accident rates within the project termini. Limited accident data is common on rural 2-lane highways with low to moderate traffic volumes. The limited amount of such data often makes traditional methods of analysis difficult. Even accident rates generated from a small sample can be misleading because they can be significantly influenced by small variances.

5. Summary Form. The accident data should be summarized by type and severity. Figure 55-8A, Accident Analysis Form, provides a typical accident summary form that may be used to analyze accidents. Figure 55- 8B, Accident Analysis Form Codes, and Figure 55-8C, Collision Diagram Codes, provide the codes which are used in conjunction with the accident summary form in Figure 55-8A.

6. Accident Analysis. Once the accident data has been compiled, the designer will need to review the data to identify accident patterns and determine possible causes for the accident patterns. The severity patterns should be examined to determine if a particular roadway or roadside feature may have contributed to the overall severity of the accidents that have occurred. Section 55-8.02 provides additional information on probable accident causes and

possible safety enhancements.

7. Contributing Factors. The contributing circumstances portion of the accident report should be summarized. This identifies possible accident causes noted by the investigating police officer at the scene of the accident. Contributing circumstances typically are categorized by human (driver) factors, environmental factors and vehicle-related factors. The contributing circumstances information is typically used to verify, add or delete possible causes developed by the "accident summary by type" procedure. In addition, the contributing circumstances information can be used to separate correctable and non-correctable accidents. In separating the accidents by these classifications, careful consideration should be made to assure that the accidents are indeed non-correctable. Figure 55-8D lists the contributing circumstances found on most accident reports, and if they are generally correctable or non-correctable through highway improvements.

8. Environmental Factors. Accidents should be summarized by environmental conditions. This procedure identifies possible causes of safety deficiencies related to the existing condition of the roadway environment at the time of the accident. Typical classifications used in the analysis include lighting conditions (daylight, dusk, dawn, dark) and roadway surface condition (dry, wet, snowy/icy, unknown). These summaries are compared to average or expected values for similar locations or areas to determine whether the occurrence of a specific environmental characteristic is greater or less than the expected value at the location. For example, a higher than expected number of wet surface accidents may be an indication of slippery pavement.

55-8.02 Probable Causes and Safety Enhancements

Probable accident causes should be defined once the accident patterns are identified. Field conditions, as determined by an on-site or photolog review or from information on the police accident report or computerized accident form, should be used to refine the list of possible causes to the most probable. The identified probable causes can then be used as a basis for selecting appropriate safety enhancements to alleviate the safety deficiency. Figure 55-8E, Accident Analysis, provides a list of probable accident causes and possible safety enhancements. This list is not all inclusive; however, it does provide a general list of possible accident causes as a function of accident patterns and appropriate safety enhancements.